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Fitzrandolph

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(54) **METHOD AND APPARATUS FOR DETECTING JAMMING SIGNAL**

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(52) **U.S. Cl.** **375/147**; 375/150; 375/371; 455/1

(58) **Field of Search** 375/140, 142, 375/143, 147, 150, 152, 224, 367, 371; 342/357.12, 442, 357.06; 455/456.1; 380/1, 42, 287, 255

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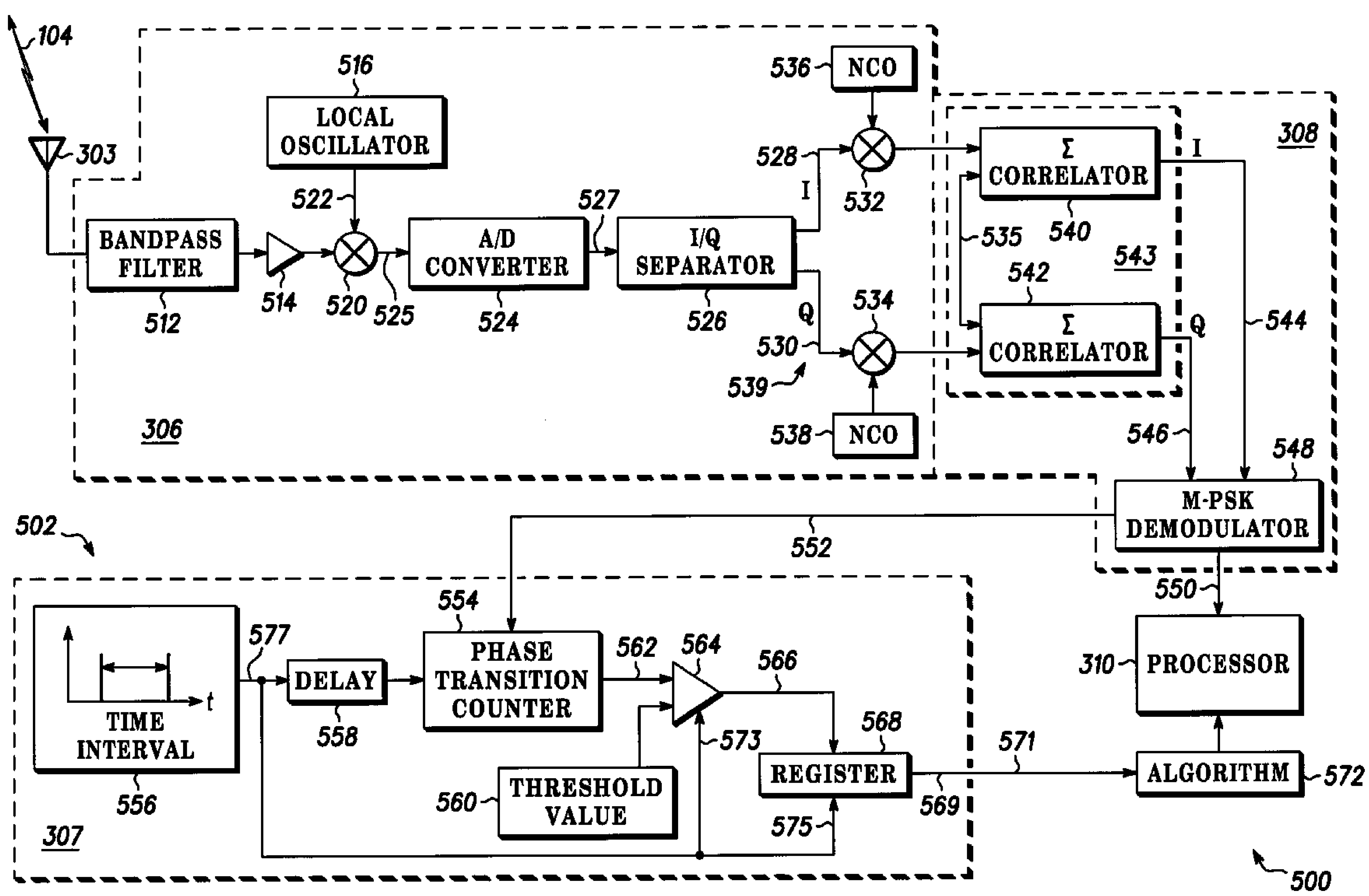
(57) **ABSTRACT**

In a wireless communication device **(106)** a method of detecting a narrowband jamming signal **(404)** includes receiving a wireless communication signal **(104)** and down-converting the wireless communication signal **(104)** to an intermediate frequency (IF) signal **(525)**. IF signal **(525)** is digitized to provide a digital signal **(527)**. Digital signal **(527)** is despread, demodulated and monitored for the number of phase transitions **(562)** occurring during a time interval **(556)**. The method further includes comparing the number of phase transitions **(562)** during the time interval **(556)** with a threshold value **(560)** and determining that the wireless communication signal **(104)** is not the narrowband jamming signal **(404)** if the number of phase transitions **(562)** during the time interval **(556)** exceeds the threshold value **(560)**, or determining that the wireless communication signal **(104)** is the narrowband jamming signal **(404)** if the number of phase transitions **(562)** during the time interval **(556)** is less than the threshold value **(560)**.

29 Claims, 5 Drawing Sheets



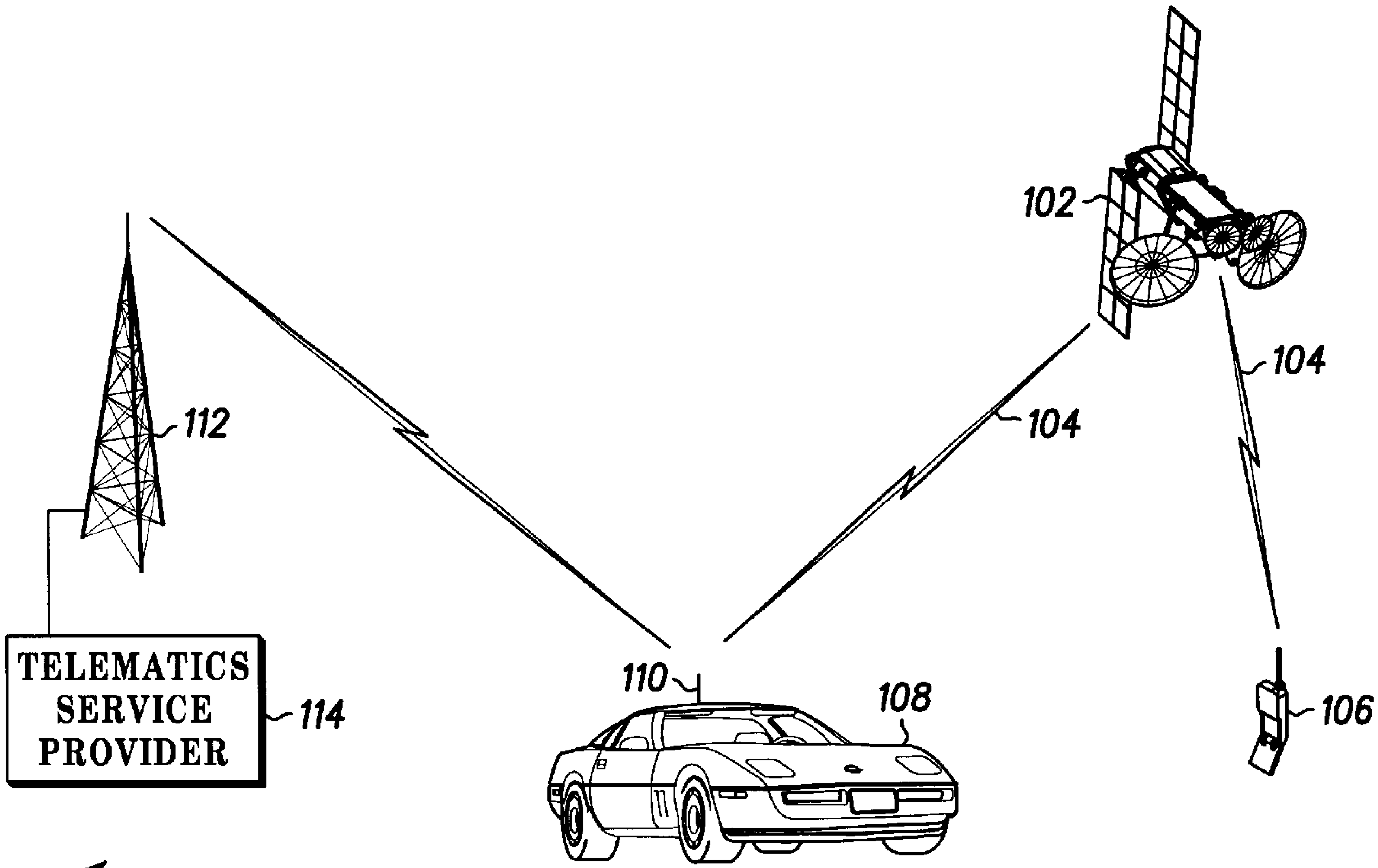

102
104
104
112
TELEMATICS SERVICE PROVIDER
114
110
108
106
100

FIG. 1

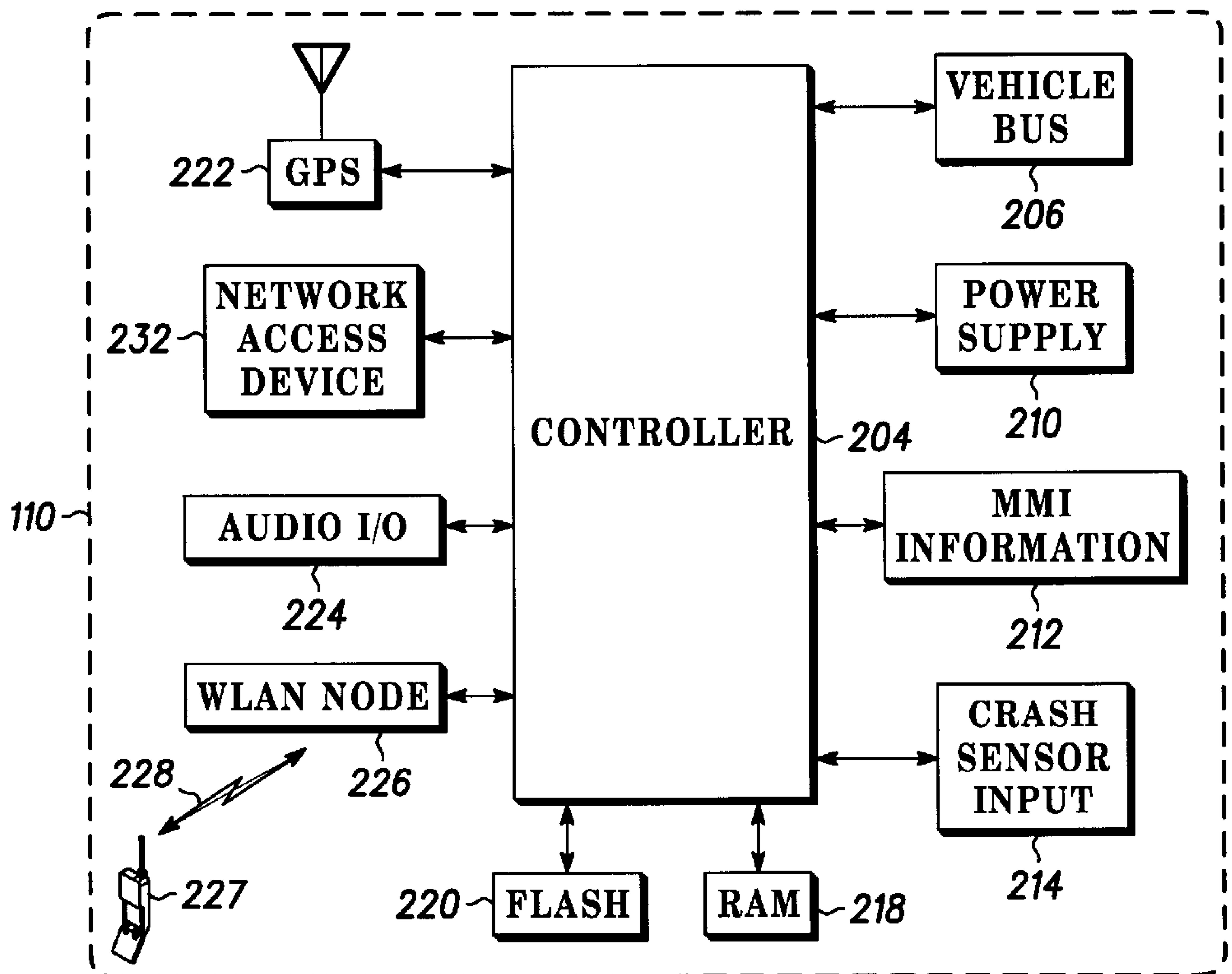

222
GPS
NETWORK ACCESS DEVICE
232
110
AUDIO I/O
224
WLAN NODE
226
228
227
CONTROLLER
204
VEHICLE BUS
206
POWER SUPPLY
210
MMI INFORMATION
212
CRASH SENSOR INPUT
214
220
FLASH
RAM
218

FIG. 2

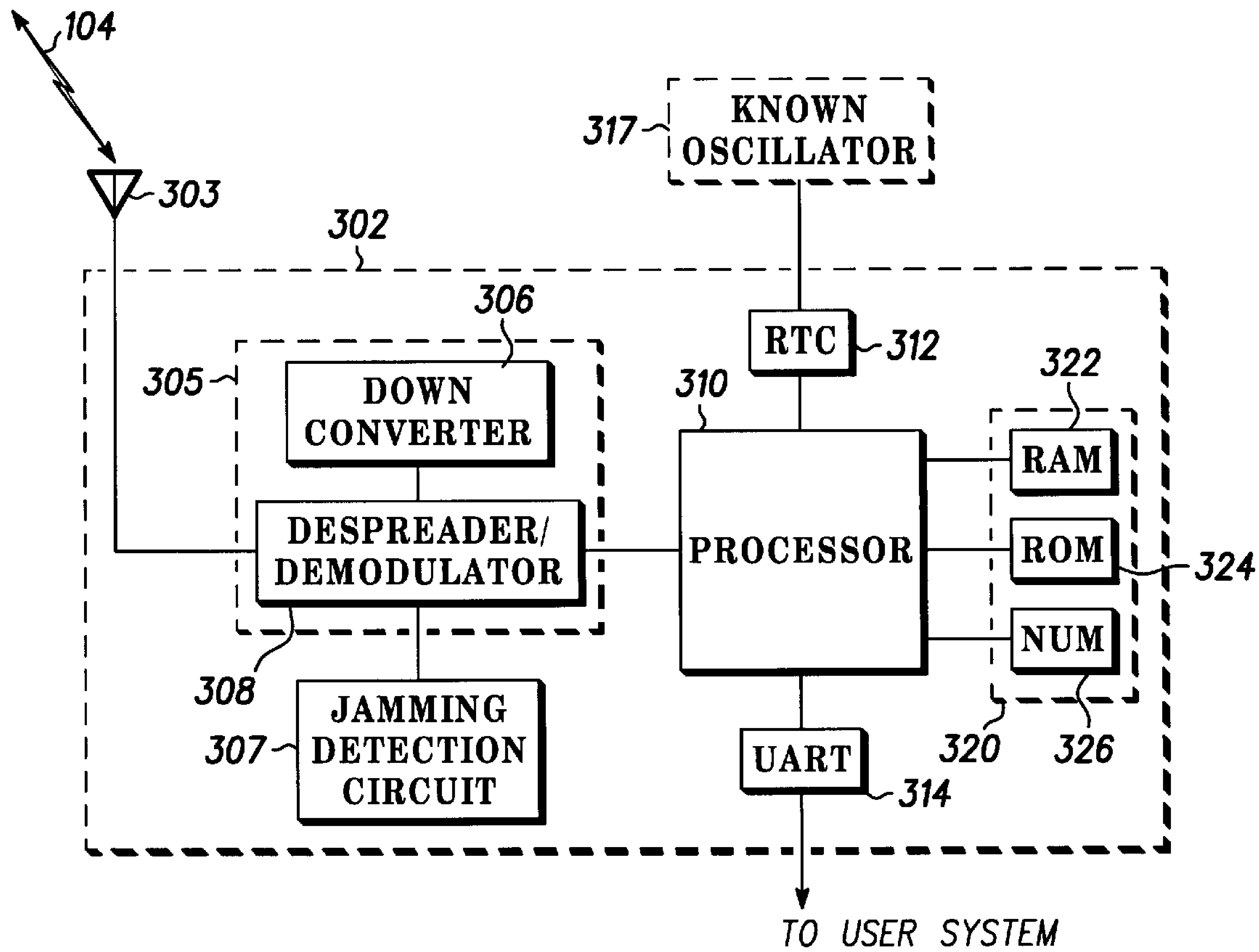

104
303
302
317
KNOWN OSCILLATOR
306
305
DOWN CONVERTER
RTC
312
310
322
DESPREADER/ DEMODULATOR
PROCESSOR
RAM
ROM
324
NUM
308
JAMMING DETECTION CIRCUIT
307
UART
314
320
326
TO USER SYSTEM

FIG. 3

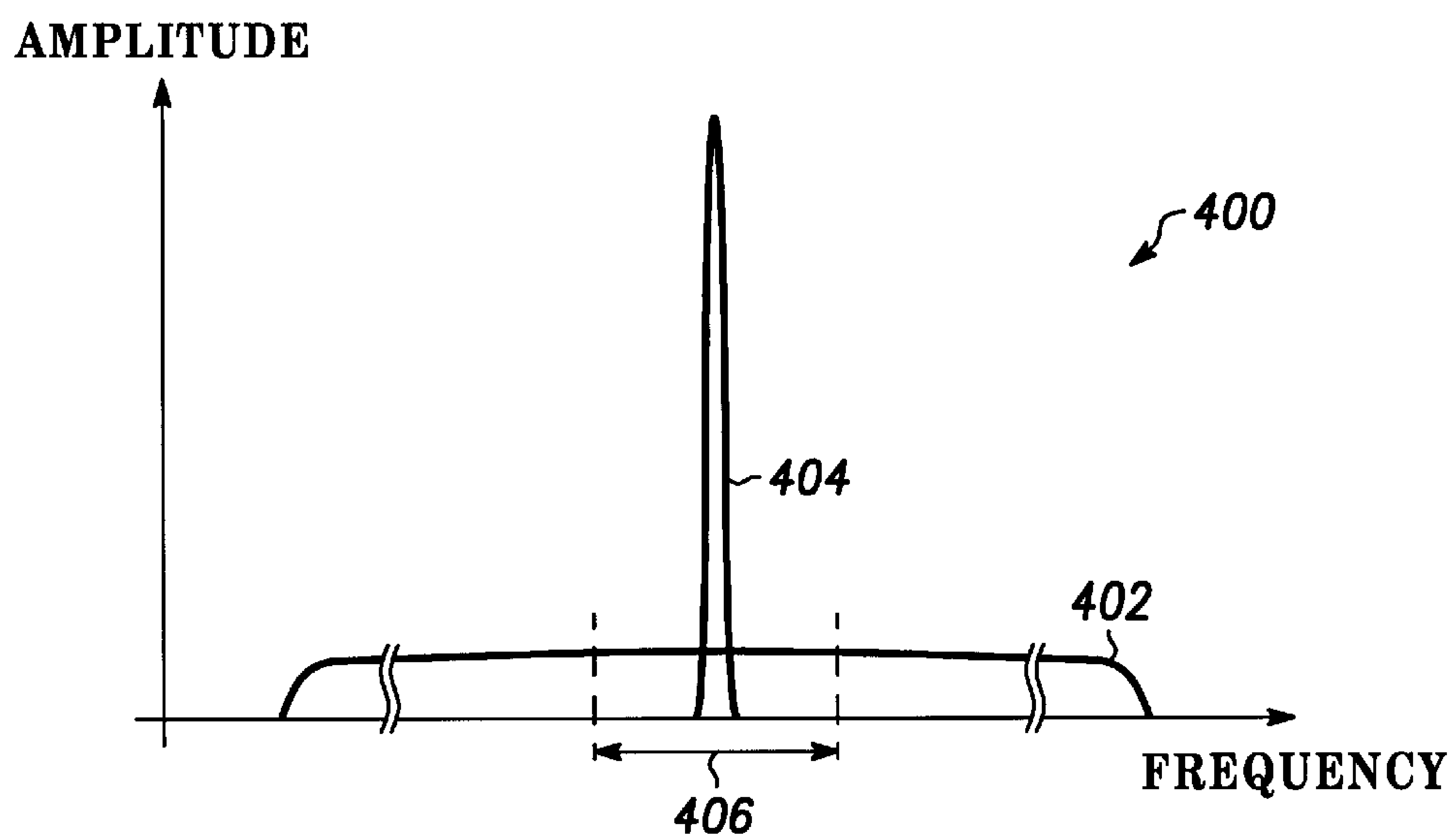

AMPLITUDE
400
404
402
FREQUENCY
406

FIG. 4

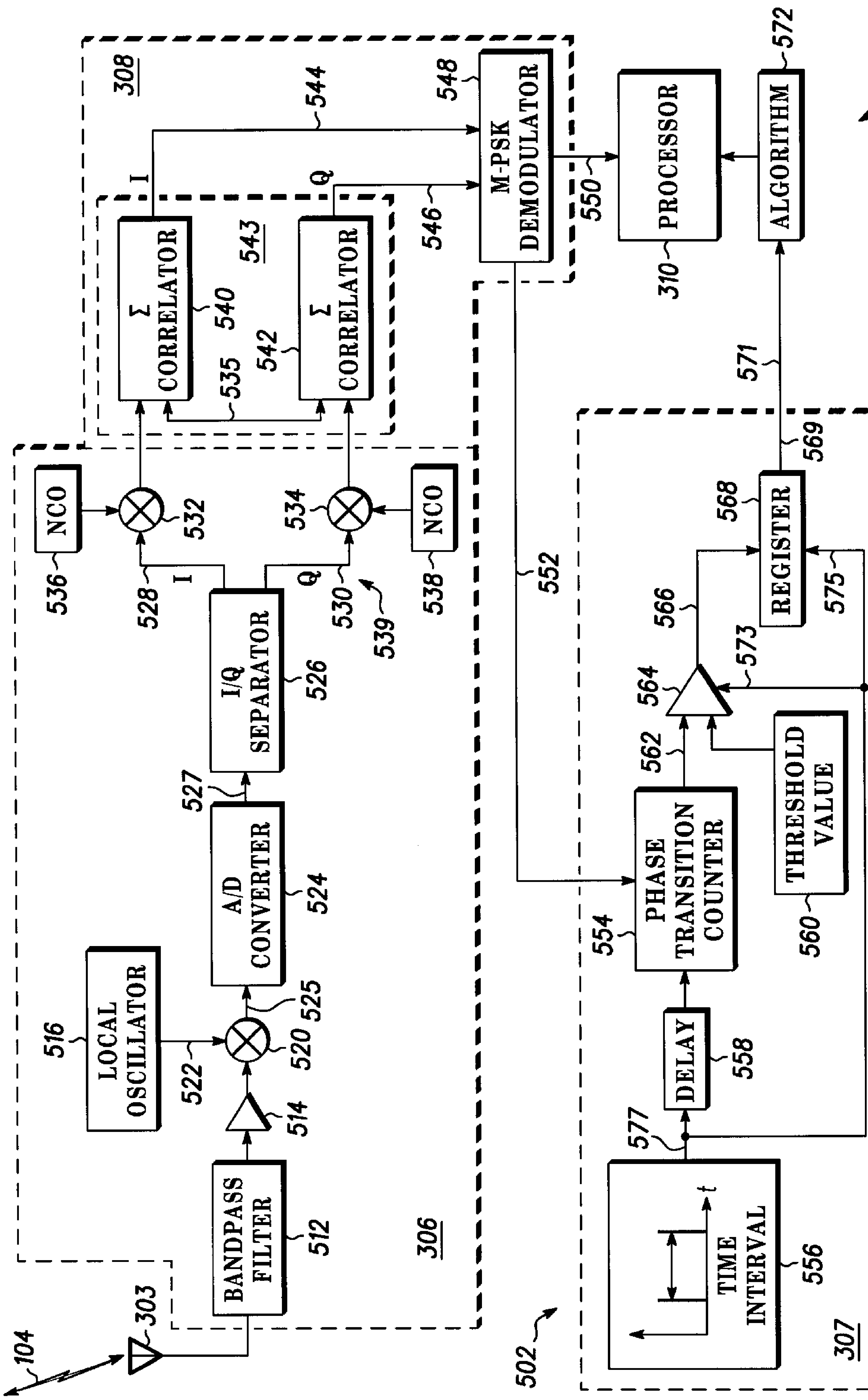

104
303
BANDPASS FILTER
512
514
LOCAL OSCILLATOR
516
522
520
525
A/D CONVERTER
524
527
I/Q SEPARATOR
526
I
Q
528
530
539
NCO
536
NCO
538
532
534
306
Σ CORRELATOR
540
Σ CORRELATOR
542
535
543
I
Q
544
546
M-PSK DEMODULATOR
548
308
550
PROCESSOR
310
ALGORITHM
572
571
552
502
TIME INTERVAL
t
556
577
DELAY
558
PHASE TRANSITION COUNTER
554
562
THRESHOLD VALUE
560
564
573
566
REGISTER
568
575
569
307
500

FIG. 5

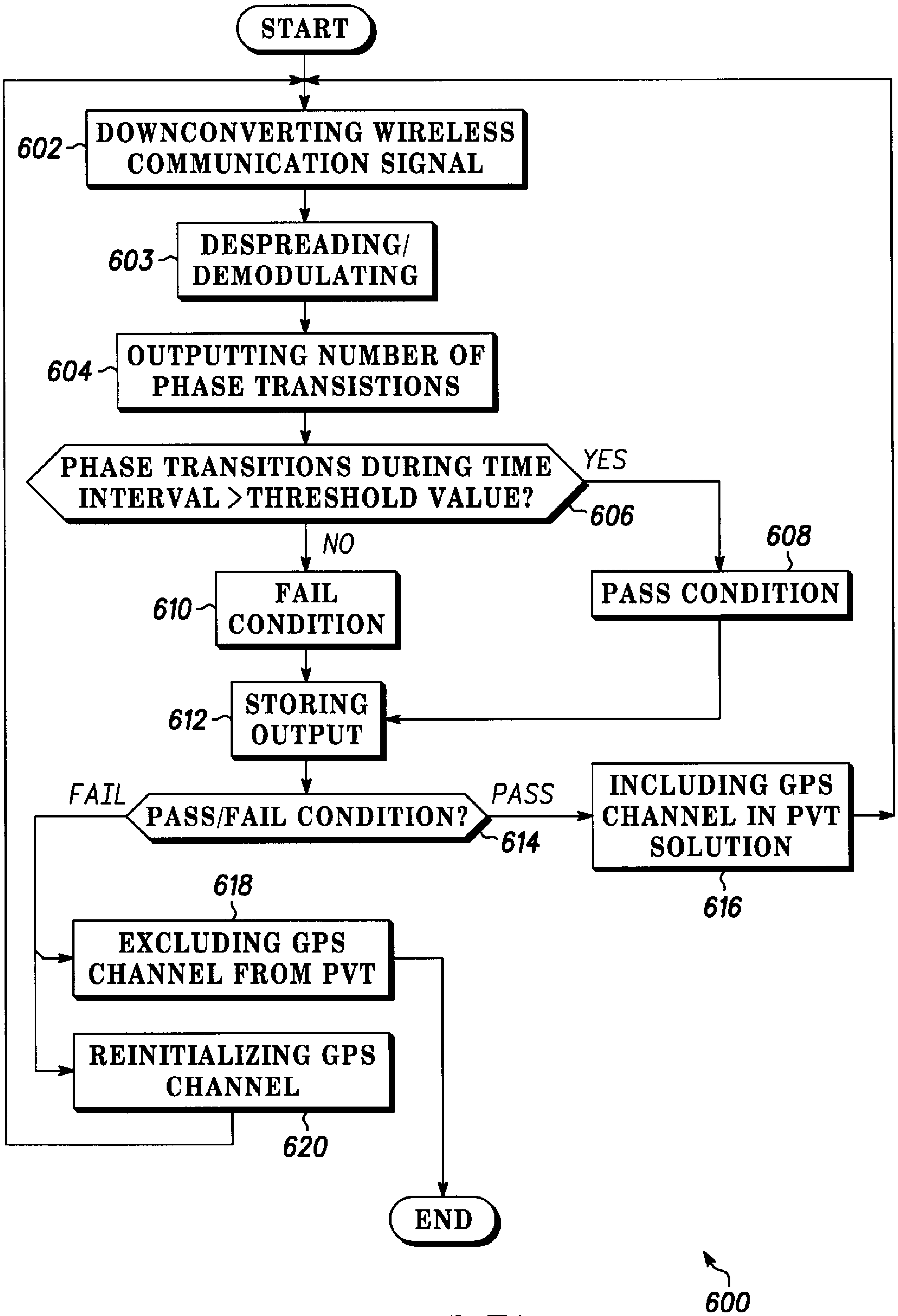

START
DOWNCONVERTING WIRELESS COMMUNICATION SIGNAL
602
DESPREADING/ DEMODULATING
603
OUTPUTTING NUMBER OF PHASE TRANSITIONS
604
PHASE TRANSITIONS DURING TIME INTERVAL >THRESHOLD VALUE?
606
YES
NO
PASS CONDITION
608
FAIL CONDITION
610
STORING OUTPUT
612
PASS/FAIL CONDITION?
614
FAIL
PASS
INCLUDING GPS CHANNEL IN PVT SOLUTION
616
EXCLUDING GPS CHANNEL FROM PVT
618
REINITIALIZING GPS CHANNEL
620
END
600

FIG. 6

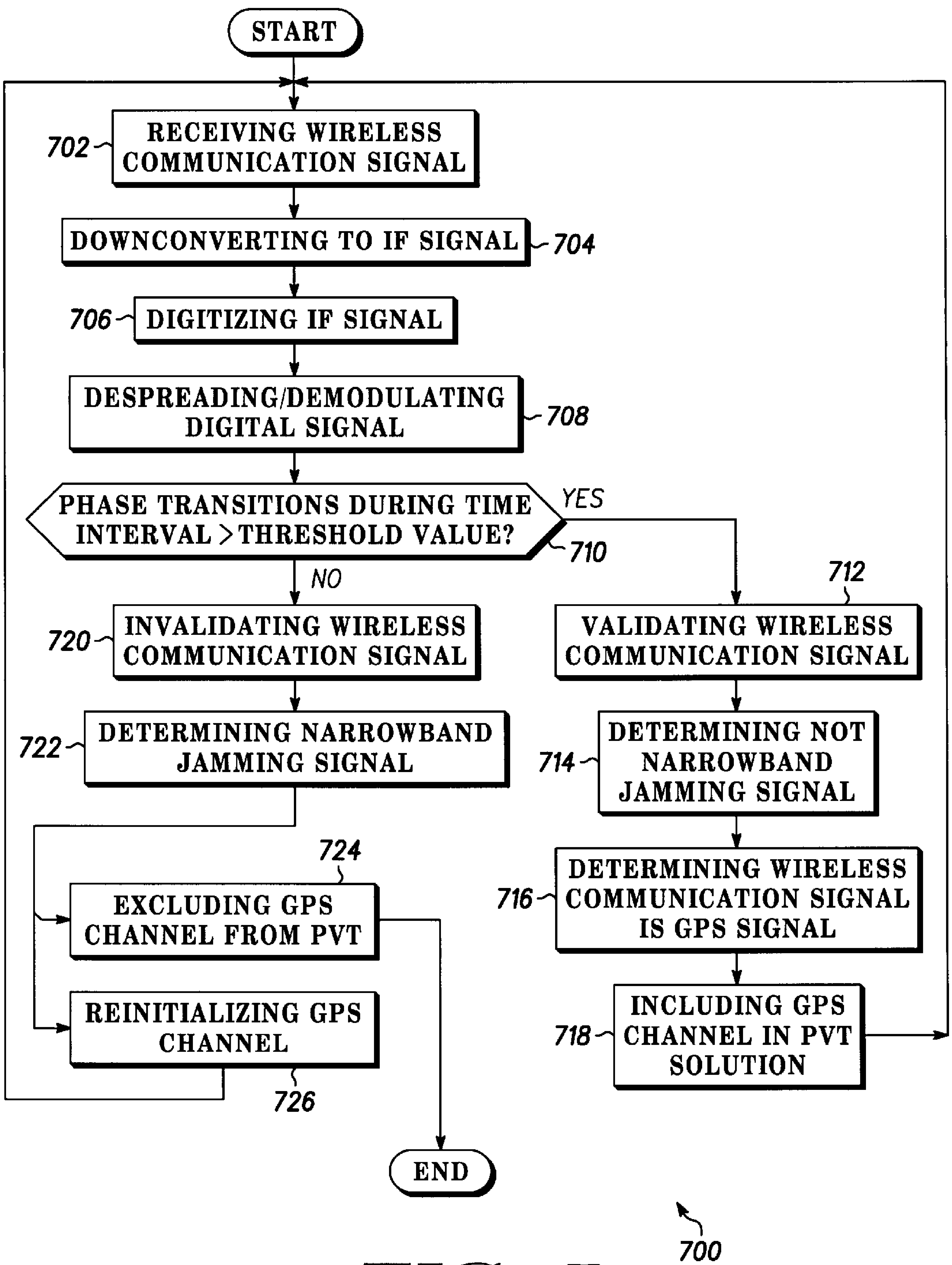

START
RECEIVING WIRELESS COMMUNICATION SIGNAL
702
DOWNCONVERTING TO IF SIGNAL
704
DIGITIZING IF SIGNAL
706
DESPREADING/DEMODULATING DIGITAL SIGNAL
708
PHASE TRANSITIONS DURING TIME INTERVAL > THRESHOLD VALUE?
710
YES
NO
INVALIDATING WIRELESS COMMUNICATION SIGNAL
720
VALIDATING WIRELESS COMMUNICATION SIGNAL
712
DETERMINING NARROWBAND JAMMING SIGNAL
722
DETERMINING NOT NARROWBAND JAMMING SIGNAL
714
EXCLUDING GPS CHANNEL FROM PVT
724
DETERMINING WIRELESS COMMUNICATION SIGNAL IS GPS SIGNAL
716
REINITIALIZING GPS CHANNEL
726
INCLUDING GPS CHANNEL IN PVT SOLUTION
718
END
700

FIG. 7

METHOD AND APPARATUS FOR DETECTING JAMMING SIGNAL

BACKGROUND OF THE INVENTION

In Direct Sequence Spread Spectrum (DSSS) systems, it is possible for a high-powered, narrowband signal to jam a DSSS receiver. Due to the nature of the demodulating process in a DSSS receiver, a strong signal going into a despreader results in a strong signal coming out of the despreader. A receiver uses the despreader output downstream for two primary purposes: 1) to demodulate transmitted data, and 2) to determine the signal strength of the DSSS signal. If a high-powered narrowband signal enters the despreader, the high amplitude output of the despreader can deceive the receiver into thinking it is still properly tracking the DSSS signal.

Prior art methods for detecting jamming includes frequency based analysis of a DSSS signal at the pre-detection stage, for example analyzing the frequency-domain representation of the received signal. This requires extensive use of the Fast Fourier Transform (FFT), which burdens the processor and memory of a receiver as the FFT output over multiple time intervals must be stored during the processing of information. A new method of jamming detection, which can be readily added to an existing receiver with no additional hardware requirement and impose a minimum burden on the processor and memory is desirable.

Accordingly, there is a significant need for an apparatus and method that overcomes the deficiencies of the prior art outlined above.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawing:

FIG. **1** depicts a system level diagram of a wireless communication network according to an embodiment of the invention;

FIG. **2** is a block diagram of a telematics communication unit according to an embodiment of the invention;

FIG. **3** is a block diagram of a wireless communication receiver according to an embodiment of the invention;

FIG. **4** is a spectral diagram according to an embodiment of the invention;

FIG. **5** is more detailed block diagram of a wireless communication receiver according to an embodiment of the invention;

FIG. **6** is flow chart of a method according to an embodiment of the invention; and

FIG. **7** is a flow chart of another method according to an embodiment of the invention.

It will be appreciated that for simplicity and clarity of illustration, elements shown in the drawing have not necessarily been drawn to scale. For example, the dimensions of some of the elements are exaggerated relative to each other. Further, where considered appropriate, reference numerals have been repeated among the Figures to indicate corresponding elements.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following detailed description of exemplary embodiments of the invention, reference is made to the accompanying drawings, which illustrate specific exemplary embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, but other embodiments may be utilized and logical, mechanical, electrical and other changes may be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. In other instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the invention.

In the following description and claims, the terms "coupled" and "connected," along with their derivatives, may be used. It should be understood that these terms are not intended as synonyms for each other. Rather, in particular embodiments, "connected" may be used to indicate that two or more elements are in direct physical, electrical, or logical contact. However, "coupled" may mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other.

For clarity of explanation, the embodiments of the present invention are presented, in part, as comprising individual functional blocks. The functions represented by these blocks may be provided through the use of either shared or dedicated hardware, including, but not limited to, hardware capable of executing software. The present invention is not limited to implementation by any particular set of elements, and the description herein is merely representational of one embodiment.

FIG. **1** depicts a system level diagram of a wireless communication network **100** according to an embodiment of the invention. In particular, a satellite **102** provides wireless communication signals **104** to a wireless communication device **106** or a vehicle **108** by way of a telematics communication unit **110**. The satellite **102** could be any communication satellite, such as a satellite for the global positioning system (GPS), which is well known in the art. In an embodiment of the invention, satellite **102** can utilize only DSSS signals. The wireless communication device **106** could be any communication device adapted to receive wireless communication signals **104**, such as a portable GPS receiver, or any device incorporating a GPS receiver, such as a cellular telephone having GPS capability. The telematics communication unit **110** preferably is adapted to communicate with another wireless communication network **112**, such as a cellular communication network, coupled to a telematics service provider **114**.

FIG. **2** is a block diagram of a telematics communication unit **110** according to an embodiment of the invention. As depicted in FIG. **2**, telematics communication unit **110** can be installed in the vehicle **108** of FIG. **1**. The telematics communication unit **110** preferably comprises a controller **204** having various input/output (I/O) ports for communicating with various components of a vehicle **108**. For example, the controller **204** is coupled to a vehicle bus **206**, a power supply **210**, a man machine interface (MMI) **212**, and a crash sensor input **214**. The connection to the vehicle bus **206** enables operations such as unlocking the door, sounding the horn, flashing the lights, etc. The controller **204** is also preferably coupled to various memory elements, such as a random access memory (RAM) **218** or a flash memory **220**. The telematics controller **204** also preferably includes a global positioning system (GPS) unit **222** which provides the location of the vehicle, as is well known in the art. The telematics controller **204** is also preferably coupled to an audio I/O **224** which preferably includes a hands-free system for audio communication for a user of the vehicle by way of a wireless communication network, such as a cellular telephone network.

Finally, the telematics communications unit **110** could include a wireless local area network (WLAN) node **226** which is also coupled to the controller **204** and enables communication between a WLAN enabled device such as a wireless communication device **227** and the telematics controller **204**. The wireless communication device **227** could communicate with the WLAN enabled controller **204**, and therefore, a network access device **232**, by any WLAN protocol, such as Bluetooth, IEEE 802.11, IrdA, or any other WLAN application, on a communication link **228**. The communication link **228** preferably provides a local, low power connection between the wireless communication device **227** and a network access device **232** of the vehicle. The network access device **232** could be, for example, a cellular telephone transceiver or other two-way wireless communication device which is well known in the art.

FIG. **3** is a block diagram of a wireless communication receiver **302** according to an embodiment of the invention. Wireless communication receiver **302** can be incorporated in the GPS unit **222** or wireless communication device **106**. Wireless communication receiver **302** is coupled to an antenna **303** and a radio frequency (RF) circuit to receive wireless communication signal **104**. Wireless communication receiver **302** further comprises a downconverter **306**, coupled to a despreader/demodulator **308**, as is well known in the art.

In an embodiment of the invention, wireless communication signals **104** can be GPS signals, which are received from GPS satellites, such as the wireless communication signals **104** from the satellite **102** shown in FIG. **1**. The despreader/demodulator **308** is coupled to a processor **310**. Processor **310** is coupled to a real time clock (RTC) **312** and a universal asyncronous receiver/transmitter (UART) **314** which communicates with a user system. For example, the UART **314** could communicate with a controller of wireless communication device **106**, controller **204** of the telematics communication unit **110**, or any other device incorporating the receiver **302**. The RTC **312** is coupled to a known oscillator **317**. Despreader/demodulator **308** is coupled to jamming detection circuit **307**, which is discussed more fully below.

Finally, the processor is coupled to a memory portion **320**. The memory portion **320** preferably comprises a random access memory (RAM) **322**, a read only memory (ROM) **324** and a non-volatile memory (NVM) **326**. The elements of receiver **302** could be incorporated on a single integrated circuit (IC), or on multiple IC's. While the known oscillator **317** is shown separate from the receiver **302**, the known oscillator **317** could be incorporated on an IC of the receiver **302**.

FIG. **4** is a spectral diagram **400** according to an embodiment of the invention. GPS satellites transmit GPS signals in two frequency bands, conventionally referred to as the L1 band and the L2 band. These are known as the GPS bands. The L1 band has a nominal carrier frequency of 1575.42 MHz, and the L2 band has a nominal carrier frequency of 1227.6 MHz. Due to the relative motion between the satellite and the observer, however, these frequencies may be Doppler shifted up or down by as much as 5 kHz. Most commercial receivers use only the L1 band, as the L2 band is used primarily for military applications.

As shown in FIG. **4**, a wireless communication signal **104** into a receiver **302** can be a GPS signal **402**, where the receiver **302** has a bandpass filter with a passband **406** to select the desired range of frequencies of GPS signal **402** for further processing. GPS signal **402** is a relatively low-strength signal with a data rate of approximately 50 bits per second (bps) and a chip rate of 1.023 million chips per second (Mchips/sec). If a much stronger narrowband jamming signal **404**, for example and without limitation, a continuous wave (CW) signal, occupies the passband **406**, the output of the despreader within the despreader/demodulator **308** will always have a high output magnitude, which will cause jamming of the GPS receiver on that channel.

Before the spreading process is done, the signal to be modulated is an M-PSK modulated signal, where M is an integer and corresponds to the number of possible phases, where each phase corresponds to a particular source data symbol. For quadrature phase shifted keyed (QPSK) signals, there are 4 possible phases, which allows for 2-bit symbols. For GPS, for example, the signal is binary phase shift keyed (BPSK), which has two possible phases, which allows for 1-bit symbols. Since the source data to be transmitted varies as a function of time, the phase of the transmitted symbol will change as a function of time also. For example, if a BPSK signal is being properly demodulated by a receiver, there will be 180 degree phase changes occurring at random times due to the random data. If a QPSK signal is being properly demodulated by a receiver, then the phase transitions are defined as phase transitions which are approximately n*(90 degrees) apart, where n is an integer from 1 to 3, which occur at random times. In effect, for a QPSK signal, there are 90-degree phase changes occurring at random times. For a GPS signal with a data rate of 50 bps, there are no more than 50 phase transitions per second, since the source data is not always alternating 1's and 0's. However, given any DSSS signal, there are an expected minimal number of phase transitions during a time interval. The minimum number is dependent upon the data rate and format of the data to be transmitted.

If receiver **302** is tracking a narrowband jamming signal **404** that is relatively high-powered compared to GPS signal **402**, there will be a small number, if any, phase transitions during a time interval. For example, if narrowband jamming signal **404** is a CW signal, there are no phase transitions during a time interval. As a result, the number of phase transitions during a time interval can be monitored to determine if a wireless communication signal **104** is a DSSS signal, for example a GPS signal **402**, or a narrowband jamming signal **404**.

FIG. **5** is more detailed block diagram **500** of a wireless communication receiver **502** according to an embodiment of the invention. As shown in FIG. **5**, wireless communication signal **104** is received at antenna **303**, which is coupled to downconverter **306**. In downconverter **306**, wireless communication signal **104** is first processed through bandpass filter **512**, which preferentially selects desired frequencies, for example those frequencies associated with a GPS signal **402**, e.g. frequencies in the L1 band or L2 band. Bandpass filter **512** is coupled to amplifier **514**, which amplifies the signal from bandpass filter **512**. Mixer **520** mixes the output of amplifier **514** with local oscillator signal **522** from local oscillator **516**. In this way, mixer **520** downconverts the frequency of the output of amplifier **514** to provide an intermediate frequency (IF) signal **525**.

Local oscillator **516** can include a frequency synthesizer, which uses a voltage controlled oscillator and a phase locked loop to produce a signal that is phase locked to a reference oscillator. Reference oscillator (not shown for clarity) can be included on the wireless communication device **106** or be provided as an additional receiver or GPS component, in which case it may be either internal or external to the IC of receiver **502**. Oscillator is typically a crystal oscillator and may be provided with temperature compensation circuitry.

After initial downconversion, IF signal **525** is converted to digital signal **527** through an analog-to-digital (A/D) converter **524**. Thereafter, digital signal **527** is separated via I/Q separator **526** into an in-phase (I) component **528** and a quadrature (Q) component **530** before entering despreader/demodulator **308**.

Next, I component **528** and Q component **530** enter a final downconversion process **539**. I component **528** enters mixer **532** and is mixed with a signal from numerically controlled oscillator (NCO) **536**. Q component **530** enters mixer **534** and is mixed with a signal from NCO **538**. The output signal from NCO **538** is essentially a phase-shifted version of the output signal from NCO **536**. The NCO **538** output signal is 90 degrees out of phase with respect to NCO **536** output signal.

In this way, bandpass filter **512**, amplifier **514**, mixer **520**, local oscillator **516**, and final downconversion process **539**comprise downconverter **306** section of receiver **502**. Downconverter **306** operates to filter out, amplify, and reduce the carrier frequencies of wireless communication signals **104**, for example GPS signal **402**, received by receiver **502**. In an embodiment, wireless communication signal **104** is a GPS signal **402** from a particular satellite **102** that typically appears in a band of frequencies with a carrier frequency of 1575.42 MHz (the nominal L1 carrier frequency) shifted by a Doppler frequency primarily caused by the satellite's motion relative to receiver **502** and oscillator drift. The corresponding GPS signal **402** after downconversion to IF signal **525** will appear in a second band of frequencies with a much lower carrier frequency. Specifically, the carrier frequency of the IF signal **525** will be the carrier frequency of the output of amplifier **514** shifted by an amount determined by the frequency of local oscillator signal **522**.

Although a particular exemplary embodiment of downconverter **306** is shown in FIG. **5**, other implementations can also be used and be within the scope of the invention. For example, while downconverter **306** is shown as having one amplifier, one bandpass filter and one mixer, a greater number of amplifiers, bandpass filters and amplifiers can be used and be within the scope of the invention.

Output of mixer **520** is converted to digital signal **527** by A/D converter **524**. Digital signal **527** enters the I/Q separator **526**. Signal I **528** and signal Q **530** enter the final downconversion process **539**. The outputs of this process enter despreader/demodulator **308**, which is comprised of despreader **543** and M-PSK demodulator **548**. Despreader **543** comprises correlators **540**, **542**. Output of mixer **532** and pseudo-random noise (PN) code **535** are coupled to correlator **540**, which generates an I component output **544**. Output of mixer **534** is also coupled with PN code **535** to correlator **542**, which generates a Q component output **546**. In an embodiment of the invention, GPS for example, the PN code **535** is a Gold code at a rate of 1.023 Mchips per second.

I component output **544** and Q component output **546** are coupled to M-PSK demodulator **548**, where the signal sampling rate is reduced from approximately 1/(predetection interval of correlators **540** & **542**) to 50 Hz. In the present embodiment, the sampling rate is reduced from 1 kHz to 50 Hz. However, other reductions in sampling rate are within the scope of the invention. The M-PSK demodulator **548** keeps track of the phase of demodulated signal **552** and outputs it to phase transition counter **554** of jamming detection circuit **307**. Phase of demodulated signal **552** can include phase information of demodulated signal, for example the actual phase of demodulated signal **552**, the change in phase of demodulated signal **552**, and the like. Demodulated signal **550** output by M-PSK demodulator **548**, for example GPS bit-stream data, and the like, is sent to processor **310** for use in receiver **502** and wireless communication device **106**. By combining data from at least four GPS satellites via four GPS channels, receiver **502** is able to compute its three-dimensional location and to determine the correct time. GPS receivers may obtain this information from multiple satellites by acquiring and tracking signals from several different GPS satellites in succession. However, many GPS receivers are provided with multiple signal processing channels, with each channel corresponding to a particular GPS satellite, so that the GPS can process GPS signals from several GPS satellites at once. In another embodiment of the invention, phase of demodulated signal **552** can originate from demodulated signal **550** with the change in phase of demodulated signal **550** computed and sent to phase transition counter **554**.

In an embodiment of the invention, phase transition counter **554** receives the phase of demodulated signal **552** as described above. Phase transition counter **554** increments the count whenever the phase of demodulated signal **552** changes. For example, if a BPSK signal is being properly demodulated by a receiver **502**, there will be approximately 180-degree phase changes occurring at random times, with phase transition counter **554** incrementing for each phase change. If a QPSK signal is being properly demodulated by a receiver, then the phase transitions are defined as phase transitions which are approximately n*(90 degrees) apart, where n is an integer from 1 to 3, which occur at random times. In effect, for a QPSK signal, there are 90-degree phase changes occurring at random times, with phase transition counter **554** incrementing for each phase change.

Number of phase transitions **562** are counted by phase transition counter **554** during time interval **556** and output to comparator **564**. At the end of each time interval **556**, the number of phase transitions **562** during time interval **556** is compared to threshold value **560** via comparator **564**. Time interval **556** can be any convenient time interval, for example, 1 second.

In an embodiment of the invention, threshold value **560** should be smaller than the nominal data bit rate for a particular DSSS system. As an example of an embodiment, a GPS signal has a nominal data bit rate of 50 bps, meaning there are no more than 50 phase transitions per second, since the source data is usually not alternating 1's and 0's. Therefore, for a receiver **502** designed to process a GPS signal **402**, threshold value **560** should be less than 50 phase transitions per second. In a preferred embodiment of the invention, threshold value **560** should be no more than 10% of the nominal data bit rate so as to avoid false indications that wireless communication signal **104** is a narrowband jamming signal **404**. In this particular embodiment, for a 50 bps GPS signal, threshold value **560** should be set at no more than 5 phase transitions per second. This example is not limiting of the invention, and any threshold value **560** is within the scope of the invention.

In an embodiment of the invention, the output of comparator **566** is stored, for example, in register **568** so as to preserve the output of comparator **566** after phase transition counter **554** is reset to zero for the next time interval **556**. In an embodiment of the invention, output of comparator **566** is either a pass condition **569** or a fail condition **571**. Pass condition **569** occurs when the number of phase transitions **562** during time interval **556** exceeds threshold value **560**. This validates wireless communication signal **104** by determining that wireless communication signal **104** is, for example, a desirous DSSS signal, GPS signal, and the like. Fail condition **571** occurs when the number of phase transitions **562** during time interval **556** is less than threshold value **560**. This invalidates wireless communication signal **104** by determining that wireless communication signal **104** is a narrowband jamming signal **404**.

At the end of each time interval **556**, signals are sent to reset elements of jamming detection circuit **307** and to initiate the number of phase transitions **562** comparison by comparator **564**. Signal **577** is sent to phase transition counter **554** to reset the number of phase transitions **562** to zero. Delay **558** is included for signal **577** to ensure that phase transition counter **554** outputs number of phase transitions **562** to comparator prior to being reset. Signal **573** is sent to initiate comparison by comparator of number of phase transitions **562** accumulated by phase transition counter **554** during time interval **556**, with threshold value **560**. Signal **575** indicates that register **568** is to poll comparator output **566**.

In an embodiment of the invention, register **568** stores and outputs a record of each of pass condition **569** and fail condition **571**. Each of these pass condition **569** and fail condition **571** can be communicated to an algorithm **572**, which can use the results of jamming detection circuit **307** to take appropriate action in conjunction with processor **310** of receiver **502**. For example, in a GPS system, if wireless communication signal **104** is validated and therefore determined to be a GPS signal **402** and not a narrowband jamming signal **404**, then the GPS channel (e.g. L1 band) corresponding to wireless communication signal **104** can be included in a GPS position, time, velocity (PVT) solution. If wireless communication signal **104** is invalidated and therefore determined to be a narrowband jamming signal **404**, one or more actions can be taken by algorithm **572**. In one embodiment, GPS channel corresponding to wireless communication signal **104** can be reinitialized and an attempt made to reacquire wireless communication signal **104** over the corresponding GPS channel. In another embodiment, GPS channel corresponding to wireless communication signal **104** can be excluded from the GPS PVT solution without channel reinitialization. In still another embodiment, fail condition **571** can be crosschecked against another jamming signal detection method for verification.

FIG. **6** is flow chart **600** of a method according to an embodiment of the invention. In step **602**, wireless communication signal **104** is downconverted to an IF signal **525**, which is then digitized to a digital signal **527** using A/D converter **524**. Also in step **602**, digital signal **527** can be separated into I and Q components by I/Q separator **526**, which are then downconverted by final downconversion process **539**. In step **603**, the I & Q outputs of the downconversion process **539** pass through despreader/demodulator **308** as described above. In step **604**, the phase of demodulated signal **552** is output from despreader/demodulator **308** to phase transition counter **554**. In an embodiment of the invention, the phase of demodulated signal **552** is output from M-PSK demodulator **548**. Phase transition counter **554** counts the number of phase transitions **562** during time interval **556**. In step **606** it is determined if the number of phase transitions **562** during time interval **556** exceeds threshold value **560**. If so, a pass condition **569** is recorded per step **608** with pass condition **569** being stored per step **612**. If not, a fail condition **571** is recorded per step **610** and stored per step **612**. As discussed above, pass condition **569** validates wireless communication signal **104** as not being a narrowband jamming signal **404** and as being a desirous DSSS signal, GPS signal, and the like. A fail condition **571** invalidates wireless communication signal **104** and indicates that wireless communication signal **104** can be a narrowband jamming signal **404**.

In step **614** it is determined if a pass condition **569** or a fail condition **571** is indicated by jamming detection circuit **307**. If a pass condition **569** is indicated, GPS channel corresponding to wireless communication signal **104** is included in a GPS PVT solution per step **616**, and wireless communication signal **104** continues to be tested by jamming detection circuit **307** as indicated by the return arrow from step **616**.

If a fail condition **571** is indicated, one or more actions can be taken as indicated by steps **618** and **620**. In step **618**, GPS channel corresponding to wireless communication signal **104** can be excluded from a GPS PVT solution. In step **620**, GPS channel corresponding to wireless communication signal **104** can be reinitialized and an attempt made to reacquire wireless communication signal **104** over the corresponding GPS channel.

FIG. **7** is a flow chart **700** of another method according to an embodiment of the invention. In step **702**, receiver **502** receives wireless communication signal **104**. In step **704**, wireless communication signal **104** is downconverted to IF signal **525** by bandpass filter **512**, amplifier **514** and mixer **520** as described above. In step **706** IF signal **525** is digitized to digital signal **527** by A/D converter **524**, separated into I and Q components by I/Q separator **526** and passed through final downconversion process **539**. In step **708**, digital signal **527** is despread and demodulated by despreader/demodulator **308** as described above to provide demodulated signal **550** and phase of demodulated signal **552**. In step **710**, it is determined if the number of phase transitions **562** of phase of demodulated signal **552** during time interval **556** exceeds threshold value **560**. If so, wireless communication signal **104** is validated per step **712** and determined not to be narrowband jamming signal **404** per step **714**. In step **716** it is determined that wireless communication signal **104** is a GPS signal **402**. In step **718**, GPS channel corresponding to wireless communication signal **104** is included in GPS PVT solution.

If the number of phase transitions **562** during time interval **556** is less than threshold value **560** in step **710**, then wireless communication signal **104** is invalidated per step **720** and it is determined that wireless communication signal is a narrowband jamming signal **404** per step **722**. In this case one or more actions can be taken as indicated by steps **724** and **726**. In step **724**, GPS channel corresponding to wireless communication signal **104** can be excluded from a GPS PVT solution. In step **726**, GPS channel corresponding to wireless communication signal **104** can be reinitialized and an attempt made to reacquire wireless communication signal **104** over the corresponding GPS channel.

While we have shown and described specific embodiments of the present invention, further modifications and improvements will occur to those skilled in the art. It is therefore, to be understood that appended claims are intended to cover all such modifications and changes as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a wireless communication device, a method of validating a wireless communication signal, comprising:
- receiving a wireless communication signal;
- downconverting the wireless communication signal to an intermediate frequency (IF) signal;
- digitizing the IF signal to provide a digital signal;
- despreading and demodulating the digital signal to provide a phase of demodulated signal;
- for the phase of demodulated signal, monitoring a number of phase transitions during a time interval;
- comparing the number of phase transitions during the time interval with a threshold value;
- validating the wireless communication signal if the number of phase transitions during the time interval exceeds the threshold value; and
- invalidating the wireless communication signal if the number of phase transitions during the time interval is less than the threshold value.

2. The method of claim **1**, wherein the wireless communication signal is a GPS signal.

3. The method of claim **1**, wherein invalidating the wireless communication signal comprises determining that the wireless communication signal is a narrowband jamming signal.

4. The method of claim **3**, wherein invalidating the wireless communication signal comprises reinitializing a GPS channel corresponding to the wireless communication signal.

5. The method of claim **3**, wherein invalidating the wireless communication signal comprises excluding a GPS channel corresponding to the wireless communication signal from a position, velocity, time (PVT) solution.

6. The method of claim **1**, wherein validating the wireless communication signal comprises determining that the wireless communication signal is a GPS signal.

7. The method of claim **6**, wherein validating the wireless communication signal comprises including a GPS channel corresponding to the wireless communication signal in a position, time, velocity (PVT) solution.

8. In a wireless communication device, a method of detecting a narrowband jamming signal comprising:
- receiving a wireless communication signal;
- downconverting the wireless communication signal to an intermediate frequency (IF) signal;
- digitizing the IF signal to provide a digital signal;
- despreading and demodulating the digital signal to provide a phase of demodulated signal;
- for the phase of demodulated signal, monitoring a number of phase transitions during a time interval;
- comparing the number of phase transitions during the time interval with a threshold value;
- determining that the wireless communication signal is not the narrowband jamming signal if the number of phase transitions during the time interval exceeds the threshold value; and
- determining that the wireless communication signal is the narrowband jamming signal if the number of phase transitions during the time interval is less than the threshold value.

9. The method of claim **8**, wherein determining that the wireless communication signal is not the narrowband jamming signal comprises determining that the wireless communication signal is a GPS signal.

10. The method of claim **9**, wherein determining that the wireless communication signal is not the narrowband jamming signal comprises including a GPS channel corresponding to the wireless communication signal in a position, time, velocity (PVT) solution.

11. The method of claim **8**, wherein determining that the wireless communication signal is the narrowband jamming signal comprises reinitializing a GPS channel corresponding to the wireless communication signal.

12. The method of claim **8**, wherein determining that wireless communication signal is the narrowband jamming signal comprises excluding a GPS channel corresponding to the wireless communication signal from a position, velocity, time (PVT) solution.

13. In a wireless communication device, a method of monitoring a GPS channel for a narrowband jamming signal comprising:
- receiving a wireless communication signal on the GPS channel;
- downconverting the wireless communication signal to an intermediate frequency (IF) signal;
- digitizing the IF signal to provide a digital signal;
- despreading and demodulating the digital signal to provide a phase of demodulated signal;
- for the phase of demodulated signal, monitoring a number of phase transitions during a time interval;
- comparing the number of phase transitions during the time interval with a threshold value;
- determining that the-wireless communication signal is not the narrowband jamming signal if the number of phase transitions during the time interval exceeds the threshold value; and
- determining that the wireless communication signal is the narrowband jamming signal if the number of phase transitions during the time interval is less than the threshold value.

14. The method of claim **13**, wherein if the wireless communication signal is the narrowband jamming signal, further comprising reinitializing the GPS channel.

15. The method of claim **13**, wherein if the wireless communication signal is the narrowband jamming signal, further comprising excluding the GPS channel from a position, velocity, time (PVT) solution.

16. The method of claim **13**, wherein if the wireless communication signal is not the narrowband jamming signal, including the GPS channel in a position, time, velocity (PVT) solution.

17. In a wireless communication device, a computer-readable medium containing computer instructions for instructing a processor to perform a method of detecting a narrowband jamming signal, the instructions comprising:
- receiving a wireless communication signal;
- downconverting the wireless communication signal to an intermediate frequency (IF) signal;
- digitizing the IF signal to provide a digital signal;
- despreading and demodulating the digital signal to provide a phase of demodulated signal;
- for the phase of demodulated signal, monitoring a number of phase transitions during a time interval;
- comparing the number of phase transitions during the time interval with a threshold value;
- determining that the wireless communication signal is not the narrowband jamming signal if the number of phase transitions during the time interval exceeds the threshold value; and

determining that the wireless communication signal is the narrowband jamming signal if the number of phase transitions during the time interval is less than the threshold value.

18. The computer-readable medium of claim **17**, wherein determining that the wireless communication signal is not the narrowband jamming signal comprises determining that the wireless communication signal is a GPS signal.

19. The computer-readable medium of claim **18**, wherein determining that the wireless communication signal is not the narrowband jamming signal comprises including a GPS channel corresponding to the wireless communication signal in a position, time velocity (PVT) solution.

20. The computer-readable medium of claim **17**, wherein determining that the wireless communication signal is the narrowband jamming signal comprises reinitializing a GPS channel corresponding to the wireless communication signal.

21. The computer-readable medium of claim **17**, wherein determining that wireless communication signal is the narrowband jamming signal comprises excluding a GPS channel corresponding to the wireless communication signal from a position, velocity, time (PVT) solution.

22. A receiver for a wireless communication device, comprising:

a downconverter for downconverting a wireless communication signal and transforming the wireless communication signal to a digital signal;

a despreader/demodulator coupled to the downconverter for converting the digital signal to a demodulated signal and outputting a phase of the demodulated signal;

a phase transition counter coupled for receiving the phase of the demodulated signal and counting a number of phase transitions during a time interval;

a comparator coupled for comparing the number of phase transitions during the time interval with a threshold value, wherein if the number of transitions during the time interval exceeds the threshold value the wireless communication signal is a GPS signal, which indicates a pass condition, wherein if the number of transitions during the time interval is less than the threshold value the wireless communication signal is a narrowband jamming signal, which indicates a fail condition, and wherein one of the pass condition and the fail condition is an output of the comparator; and

a means for storing an output of the comparator.

23. The receiver of claim **22**, further comprising an algorithm for utilizing the output of the comparator, wherein if the wireless communication signal is the GPS signal, the algorithm includes a GPS channel corresponding to the wireless communication signal in a position, time, velocity (PVT) solution.

24. The receiver of claim **22**, further comprising an algorithm for utilizing the output of the comparator, wherein if the wireless communication signal is the narrowband jamming signal, the algorithm reinitializes a GPS channel corresponding to the wireless communication signal.

25. The receiver of claim **22**, further comprising an algorithm for utilizing the output of the comparator, wherein if the wireless communication signal is the narrowband jamming signal, the algorithm excludes a GPS channel corresponding to the wireless communication signal from a position, velocity, time (PVT) solution.

26. A receiver for a wireless communication device, comprising:

a means for downconverting a wireless communication signal and transforming the wireless communication signal to a demodulated signal;

a means for outputting a number of phase transitions during a time interval for the demodulated signal;

a means for counting the number of phase transitions during the time interval;

a means for comparing the number of phase transitions during the time interval with a threshold value, wherein if the number of transitions per the time interval exceeds the threshold value the wireless communication signal is a GPS signal, which indicates a pass condition, wherein if the number of transitions per the time interval is less than the threshold value the wireless communication signal is a narrowband jamming signal, which indicates a fail condition, and wherein one of the pass condition and the fail condition is an output of the comparator; and

a means for storing an output of the comparator.

27. The receiver of claim **26**, further comprising a means for utilizing the output of the comparator, wherein if the wireless communication signal is the GPS signal, the means for utilizing the output operates to includes a GPS channel corresponding to the wireless communication signal in a position, time, velocity (PVT) solution.

28. The receiver of claim **26**, further comprising a means for utilizing the output of the comparator, wherein if the wireless communication signal is the narrowband jamming signal, the means for utilizing the output operates to reinitializes a GPS channel corresponding to the wireless communication signal.

29. The receiver of claim **26**, further comprising a means for utilizing the output of the comparator, wherein if the wireless communication signal is the narrowband jamming signal, the means for utilizing the output operates to excludes a GPS channel corresponding to the wireless communication signal from a position, velocity, time (PVT) solution.

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